Attachment 2

CHLE-006: STP Material Calculations

PROJECT DOCUMENTATION COVER PAGE

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Title: STP Material Calculations		
Project: Corrosion/Head Loss Experiment (CHLE) Program		Date: 15 August 2012
Client: South Texas Project Nuclear Operating Company		

Summary/Purpose of Analysis or Calculation:

A survey of materials within containment at South Texas Project Nuclear Operating Company (STP) was performed to identify material that may leach corrosion or dissolution constituents into the pool solution as a result of a Loss of Coolant Accident (LOCA). This survey was performed to identify materials to include in the Chemical Head loss Experiment (CHLE) analyses and to determine the ratio of material surface area to solution volume [1] for testing purposes.

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Revision	Date	Description
0	3/12/2012	Original document
1	8/14/2012	Revised to resolve internal comments

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Definitions and Acronyms

RCB	Reactor Containment Building
RCS	Reactant Cooling System
RWST	Refueling Water Storage Tank
SI	Safety Injection
ECCS	Emergency Core Cooling System
LOCA	Loss of Coolant Accident
STP	South Texas Project
CHLE	Chemical Head Loss Experiments
ICE	Integrated Chemical Effects

1 Purpose

A survey of materials within containment at South Texas Project Nuclear Operating Company (STP) was performed to identify materials that may leach corrosion or dissolution constituents into the containment pool solution as a result of a Loss of Coolant Accident (LOCA). This survey was performed to identify materials to include in the Chemical Head loss Experiment (CHLE) analyses and to determine the ratio of material surface area to solution volume [1] for testing purposes. These values are important in conducting a risk informed approach in evaluation of potential safety issues after a LOCA. The initial pool chemistry and the corrosion or dissolution constituents within the pool solution may react to form chemical precipitates that may negatively impact head loss across the sump strainer, resulting in failure of the Emergency Core Cooling System (ECCS). An accurate assessment of materials that will leach corrosion or dissolution constituents into the pool solution and the ratio of material surface area to volume within containment will allow the CHLE analyses to investigate the most probable pool chemistry of a LOCA; thus determining the most realistic consequence of chemical reactions on head loss across the sump strainer as a result of LOCA conditions

2 Methodology

A survey of materials in containment was conducted at STP. Surface areas or volumes of materials within containment were determined and reviewed for possible exposure to the containment pool solution. Materials with very low surface area or probability of exposure to the pool solution were eliminated from the list of materials to be included in the CHLE analyses. For materials to be included in the CHLE analyses, ratio of surface areas or volumes of materials to the pool volume [1] were determined using the following equation.

$$M_{chle} = \frac{V_{chle}}{V_{stp}} M_{stp}$$

Where M_{chle} is the material surface area or volume to be included in the CHLE analyses, V_{chle} is the volume of the solution in the tank for the CHLE analyses, V_{stp} is the steady-state volume of the pool within the STP containment, and M_{stp} is the material surface area or volume in containment.

3 Design Input and Analyses

The following data was obtained from a survey of material identified to be present in containment at STP. Materials within containment that can leach metals into the containment pool are divided between non-submerged and submerged surfaces. Non-submerged material surfaces are those exposed to the containment spray during a LOCA. Although some condensation may remain on equipment and material above the containment flood level, the amount of corrosion products contributed from this material is relatively small compared to the corrosion product generated by submerged materials. With the exception of fiberglass insulation, the division of submerged and non-submerged materials is not affected by break type. Materials found to exist within containment at STP are as listed below:

- Aluminum – from valve actuator components and scaffolding
- Fiberglass (Nukon and Microtherm) –used as insulation on pipes
- Concrete – represented exposed concrete surfaces
- Zinc – in galvanized steel and in zinc-based protective coatings
- Lead – permanent lead shielding blankets
- Copper – wiring, cables, and tubes of the fan coolers
- Latent debris – dirt and lint for air flowing into containment vents
- Carbon steel – component of structural steel, steam generators, piping, etc.

Aluminum and zinc, primarily in the form of galvanized steel or non-top coated inorganic zinc based primer, have been identified as the materials most susceptible to corrosion following a LOCA [2-4]. Lead [5] and carbon steel [4] may also corrode within the expected pH range of about 4.5 – 7.5 [6] following a LOCA, releasing metal ions into the pool solution. Fiberglass and concrete can leach constituents such as calcium and silicon into solution [4], which may produce chemical precipitates in the tri-sodium phosphate (TSP) buffered pool solution. Copper and iron (from steel) are relevant because they may affect the corrosion rates of other materials, such as aluminum [7]. Since all the above materials exist within STP containment and are expected to be present within the pool chemistry if exposed to the pool solution, all were evaluated to determine available surface area and probable exposure to the pool solution.

The pool volume at STP varies depending on the volume of water in the reactor cooling system (RCS), refueling water storage tanks (RWST), and safety injection accumulators. The RCS and RWST contribute to the pool volume in all LOCAs. The accumulators do not discharge in small break LOCAs (SBLOCAs), and therefore SBLOCAs technically have a smaller pool volume and therefore larger ratio of material to pool volume than other sizes of LOCAs. However, the accumulators only contribute about 4 percent of the pool volume so the effect is relatively minor. The pool volume for LBLOCA and MBLOCA were calculated to be 71,778 ft^3 at 21 °C [1]. The pool volume for a SBLOCA was calculated to be 61,949 ft^3 at 21 °C [1].

3.1 Aluminum

3.1.1 STP Survey

Sources of aluminum in containment include structures such as scaffolding and small components such as valves and aluminum coatings. Most of these materials are above the containment pool elevation, but may be exposed to containment sprays. Both integrated and separate effects tests have shown that the corrosion of aluminum can be significant and may cause precipitates [4, 8, 9]. There are 5,567 ft^2 (10% submerged and 90% non-submerged) of aluminum in containment at STP[10]. This corresponds to a ratio of aluminum surface area to pool volume of 0.078 ft^2/ft^3.

3.1.2 CHLE Test Parameter

Based on the information obtained from the STP survey for aluminum, the surface area of aluminum in the CHLE tests will be 2.64 ft^2 in the vapor space (unsubmerged, subjected to sprays) and 0.47 ft^2 submerged in the pool solution.

3.2 Fiberglass insulation

3.2.1 STP Survey

There are two type of fiberglass insulation in solution: (1) Nukon and (2) Microtherm. Nukon insulation is classified as E-glass which is an amorphous material containing silicon dioxide, calcium oxide, aluminum oxide and boric oxide[4]. Microtherm insulation is classified as amorphous silica material which contains materials made up of predominately amorphous silica with a small percentage of E-glass[4]. The amount of fiberglass insulation within containment is determined by break type and is listed in Table 2.

Table 1: Ranges of ratio values for volume of materials to pool solution as a function of break type

Break type	Nukon Ratio (ft^3/ ft^3)	Microtherm Ratio (ft^3/ ft^3)
SBLOCA	Awaiting information	
MBLOCA	8.36E-04	0
LBLOCA		

3.2.2 CHLE Test Parameter

The amount of insulation is a function of break type which results in a range of material volumes. This range is dictated by the break sizes that fall within the category of LOCA scenarios. The amount of insulation material to be used in each of the 30 Day tank test is determined by debris generation calculations by the CASA Grande program.

Table 2: Ratio of volume of materials to pool solution in the CHLE analyses

Fiberglass Type	**SBLOCA (ft^3)**	**MBLOCA (ft^3)**	**LBLOCA (ft^3)**
Nukon		60	
Microtherm		0	

3.3 Concrete

3.3.1 STP Survey

Most concrete surfaces in within containment are coated [11]. However, some uncoated surfaces could be exposed to the pool or spray water by direct jet impingement within the zone of influence (ZOI). Also, there are some concrete surfaces with unqualified or degraded qualified coatings which may fail.

Awaiting calculation from Alion

Also, bench test will be done to characterize metals leaching from concrete. As shown by the evaluation of Table 3 (Appendix A) very little calcium (<0.5 mg/L) in solution theoretically may be required to form a calcium phosphate precipitate in a TSP buffered system, but depends on temperature and pH. Therefore evaluating leaching rates of metals, specifically calcium, from the concrete is necessary.

Table 3: Calcium concentration required to form precipitation.

Test Case	TSP Concentration (mg/L)	Boron Concentration (mg/L)	pH[a]	Calcium Concentration (mg/L)
1	4032	2486	7.33	0.36
2	4032	2659	7.26	0.41
3	4032	2897	7.18	0.48
4	4435	2486	7.36	0.31

[a] Value reference to 21 C., value determined using STP operating median boron concentration and STP representative TSP concentration
[B] Log K = -28.92 [12]

3.3.2 CHLE Test Parameter

The concrete used for the CHLE tests will be made at the University of New Mexico (UNM)following the procedure provided by Westinghouse and used for the ICET tests [13]. The UNM concrete was be subjected to leaching bench test for comparison with a concrete core obtained from a nuclear power plant to evaluate leaching differences due to material preparation.

3.4 **Latent debris**

3.4.1 STP Survey

This material type accounts for dust and fibers that exist in containment as a result of environmental conditions. The maximum value of latent debris in STP containment has been determined to be 170 lb. dirt/dust and 30 lb. fiber [14]. This corresponds to a mass to volume ratio of 0.002 lb/ft^3 for dirt/dust and 0.0004 lb/ft^3 for fiber in containment. While it is known that the TSP buffered system may be sensitive to the addition of metals to solution, it is unknown if the soil leaches any attributable concentration of metals. Therefore, bench test will be done to evaluate metal leaching from the STP soil.

3.4.2 CHLE Test Parameter

Latent debris is defined as fiber and dust. The fiber used for Latent debris is Nukon insulation and will be taken into account within the total fiberglass added to tests. The dust used in the CHLE analyses is soil obtained from the STP site using the standard environmental sampling procedure [15]. The use of the material within the 30 Day CHLE test will be evaluated by bench test that investigate metal leaching. Any detectable metal leaching will be incorporated as a salt in the CHLE tank test.

3.5 Zinc (Galvanized Steel and Coating)

3.5.1 STP Survey

Galvanized steel and zinc based paints or coatings are sources of zinc within containment. There are 273,749 ft^2 (10% submerged and 90% non-submerged) of galvanized steel in STP containment [10]. This quantity corresponds to a surface area to volume ratio 3.81 ft^2/ft^3. There are 417,839 ft^2 (10% submerged and 90% non-submerged) of inorganic coated zinc steel within containment at STP [16]. This quantity corresponds to a surface area to volume ratio of 5.82ft^2/ft^3.

These numbers are the conservative quantities. They are currently under review by the team to determine nominal quantities.

3.5.2 CHLE Test Parameter

The inclusion of galvanized steel and zinc coated material in the LBLOCA 30-day test is currently under review by the project team. If they are included, the surface area of galvanized steel in the CHLE tests will be X ft^2 in the vapor space (unsubmerged, subjected to sprays) and X ft^2 submerged in the pool solution. The surface area of zinc coated material in the CHLE tests will be X ft^2 in the vapor space (unsubmerged, subjected to sprays) and X ft^2 submerged in the pool solution.

3.6 Copper

3.6.1 STP Survey

Various source of copper are found in containment at STP. These sources include wiring, cables, and tubes of the fan coolers [17].

3.6.2 CHLE Test Parameter

While copper is present in STP containment, none of it will be submerged during a LOCA. In addition, significant quantities of the unsubmerged copper will be protected from spray impingement. Copper cable and wiring will not be subjected to spray as long as some insulation is in place.

As a result of all these factors, copper is excluded from the long-term CHLE tests. However since it is known that copper ma y accelerate aluminum corrosion [7], the effects of copper on aluminum corrosion under STP conditions will be investigated in short-term bench-scale corrosion tests.

3.7 Lead

3.7.1 STP Survey

Lead exists in STP containment in two forms: (1) lead blankets and (2) lead pipe insulation. There are approximately 500 lead blankets (1 ft x 3 ft) in containment (45 % are submerged and 55% not submerged) [18]. The equivalent thickness for a lead sheet in the blanket is 3/16 [19]. These lead blankets are stored in drums with holes to prevent them from floating away if containment floods, but the sources of lead are sealed within vinyl-laminated nylon covers which provide a protection barrier between the material and pool solution.

The lead pipe insulation is sparsely present in containment as illustrated by Figure 1. The volume/mass values associated with the locations as listed in Figure 1 are listed in Table 1. Give that only three locations within containment have lead pipe insulation, the probability that they will be in the zone of influence is relatively low [20]. Since the contribution of lead from the pipe insulation is not a likely occurrence in a LOCA , the probable contribution from this material to the pool solution is neglected.

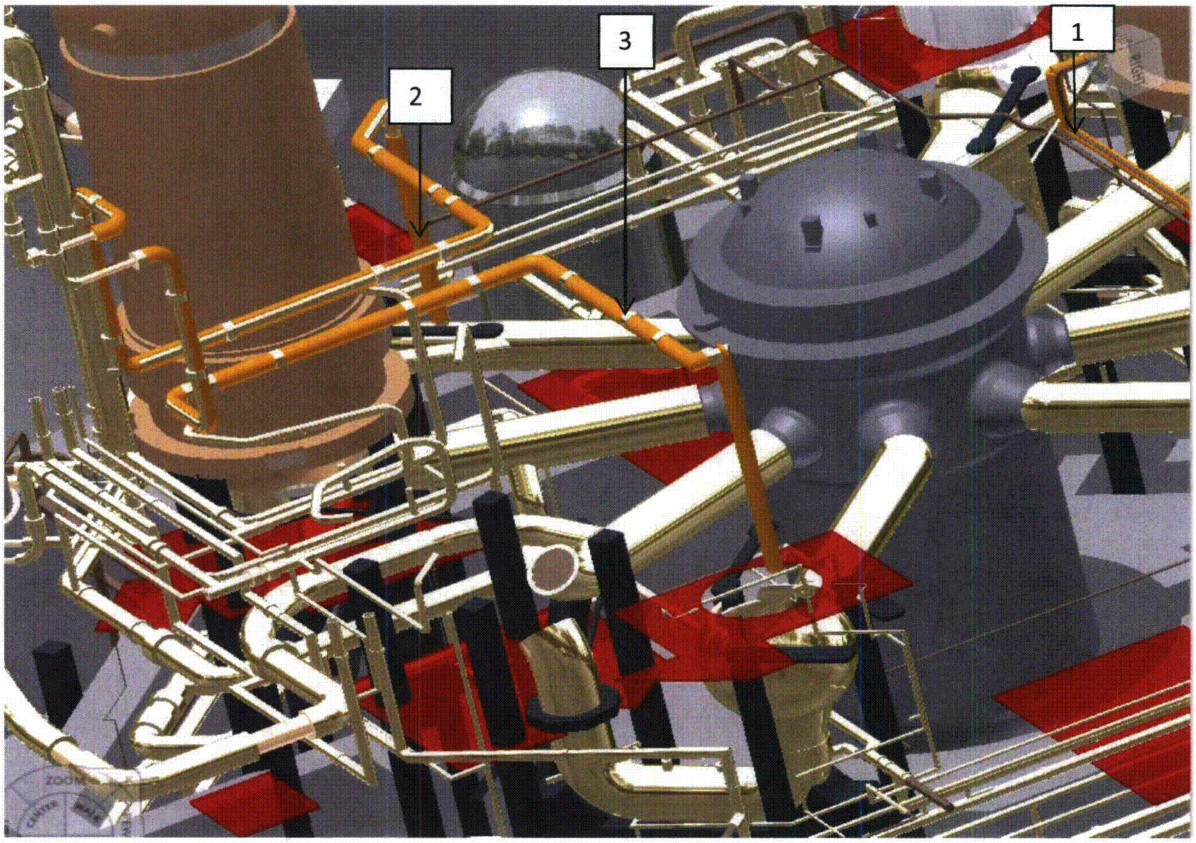

Figure 1: Simplified CAD image showing locations of lead insulated pipes are indicated in yellow.

Table 4: Volume and mass of lead insulation within STP containment

Number	Official Name	Mass (lb_m)	Volume (ft^3)
1	4CV-10010-BB1	930.7771	14.90962
2	4RC-1123-BB1	1437.241	23.02239
3	4RC-1422-BB1	1399.997	22.42536
Total	Lead Blanket Insulation	3768.015	60.35737

A literature search of lead precipitate using ions known to exist in solution as a guide (regardless of concentration) was done to identify possible precipitates and gather thermodynamic information associated with the solubility limits, Table 5. Since lead can form a variety of precipitate products in the pool with, some which theoretically require very little soluble lead (lead phosphates and lead chlorides) in solution (Table 6), it was determined that bench test will be performed to characterize lead corrosion in the CHLE pool chemistry and the formation of precipitates. It should also be noted, however, that phosphate is commonly used as a corrosion inhibitor for lead.

Table 5: Lead precipitate and associated thermodynamic data associated with solubility

Solids	Log K	Sources
$Pb(BO_2)_2(s)$	6.5192	NIST [12]
$Pb(OH)_2(s)$	8.15	MTQ3.11[21]
$Pb_2O(OH)_2(s)$	26.19	NIST [12]
$Pb_3(PO4)_2(s)$	-43.53	NIST[12]
$PbHPO_4(s)$	-23.805	NIST [12]
$PbO{:}0.3H_2O(s)$	12.98	MTQ3.11[21]
$PbCl_2$	-4.78	NIST [12]
$PbSO_4$	-7.79	NIST [12]
Solid	Solubility 1[A] (mg/L)	Solubility 2 [B] (mg/L)
$Pb(C_2H_3O_2)_2$[22]	551,006	2,185,084
$Pb(NO_3)_2$ [23]	565,000	1,270,000

[A] Solubility 1 for lead acetate is at 25 C and for Lead Nitrate it is at 20 C
[B] Solubility 2 for lead acetate is at 50 C and for Lead Nitrate is at 100 C

Table 6: Lead concentration to form lead phosphate precipitate using STP representative chemistry

Test Case	TSP Concentration (mg/L)	Boron Concentration (mg/L)	pH	lead Concentration (mg/L)
1	4032	2486	7.33	2.50E-05
2	4032	2659	7.26	2.87E-05
3	4032	2897	7.18	3.38E-05
4	4435	2486	7.36	2.14E-05

3.7.2 CHLE Test Parameter

While there is a significant surface area of lead and copper available in containment, lead will be excluded from the CHLE analyses since it is not directly exposed to spray or pool solution and the probability of material exposure due to destruction of protective outer layers is very low. However, since lead is highly insoluble, bench test will be performed to investigate lead corrosion under STP conditions.

3.8 **Uncoated Carbon Steel**

3.8.1 STP Survey

Uncoated carbon steel is generally present in containment as structural supports. 168,836 ft^2 (10% submerged and 90% non-submerged) is present in STP containment [16]. This quantity corresponds to a surface area to volume ratio of 2.35 ft^2/ft^3.

3.8.2 CHLE Test Parameter

While there is a significant amount of carbon steel in containment, previous research found that carbons steel corrosion occurred in insignificant amounts [9]. The ICET tests contained 0.15 ft^2/ft^3 of carbon steel, with 34 percent of the material submerged and 66 percent in the vapor space. The unsubmerged uncoated steel coupons had very little change in weight, with changes ranging from +1.3 to -0.4 g, compared to a mean pre-test weight of 1025 g. The submerged uncoated steel coupons in Test #1 (high pH) had a weight change of -23.3 g, but had very little weight change in the remainder of the tests (ranging from +1.4 to -1.1 g). In ICET Test #2, which corresponded most closely to the STP conditions, the unsubmerged coupons gained 1.3 g and the submerged coupons gained 1.4 g of weight. Iron concentrations remained nearly undetectable throughout the full duration of all the ICET tests. The highest concentrations of iron were less than 0.1 mg/L, during the first few days of ICET Test #3. Iron was undetectable during the entire ICET Test #2.

Based on the previously mentioned results, uncoated carbon steel will not be included in the CHLE tank tests.

4 **Summary**

A survey of material in containment at STP was performed. For materials that are expected to contribute to the containment pool chemistry, a ratio of surface area or volume of material to the volume of solution in containment at STP was determined. These ratios were used to determine the quantity of materials to include in the 30 Day CHLE tank test, Tables 4 and 5. This approach provides accurate materials and quantities to include in the integrated test as compared to previous evaluations. This approach allows for focus on materials of concern and probable chemical reactions associated with those materials.

Table 7: Surface area of materials in the CHLE analyses

Material	Surface area(ft^2)	
	Submerged	**Non-submerged**
Aluminum	0.47 ft^2	2.64 ft^2
Galvanized Steel		
Zinc coating		
Concrete	TBD	TBD
Latent debris		
Latent debris dirt contribution		

Table 8: Volume of materials in the CHLE analyses

Fiberglass Type	SBLOCA (ft^3)	MBLOCA (ft^3)	LBLOCA (ft^3)
Nukon		60	
Microtherm		0	

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CHLE-006 STP Material Calculation

Appendix A

Boron concentrations and TSP concentration from evaluation of STP operating Record

30 Day Median (mg/L)		
Source	Unit 1	Unit 2
	Median	Median
RCS	1218	1372
Accum A	2906	2931
Accum B	2922	2930
Accum C	2925	2924
RWST	2925	2941

Statistical Range (mg/L)				
Source	Unit 1		Unit 2	
	Minimum	Maximum	Minmum	Maximum
RCS	35	2797	3.7	3105
Acc A	2767	2947	2914	2951
Acc B	2906	2933	2917	2950
Acc C	2906	2942	2904	2952
RWST	2895	2958	2916	2962

TSP Information			
	Min	Max	
TSP (lb)	11,500	15,100	
TSP (lb Moles)	30.2632	39.7368	
Pool Volume (ft^3)	71,778		
Max TSP used in CHLE test - CHLE (g/L)		3.368105282	2.159041847
Min TSP, not used (g/L)		2.565113294	1.644303394

Division of Solution Volumne			
Source	Pool Contribution	Water Vol (L)	
RCS	14%	278,306	
Acc A	1.7%	35,029	
Acc B	1.7%	35,029	
Acc C	1.7%	35,029	
RWST	81%	1,649,121	
Check	100%	2,032,515	good

30 Day B Median (mM)		
Source	Unit 1	Unit 2
	Median	Median
RCS	112.66	126.91
Acc A	268.80	271.15
Acc B	270.23	271.01
Acc C	270.58	270.46
RWST	270.52	272.04

30 Day Median (Moles Boron in each source)		
Source	Unit 1	Unit 2
	Median	Median
RCS	31354.78	35319.18
Acc A	9415.91	9498.36
Acc B	9466.13	9493.20
Acc C	9478.41	9473.94
RWST	446,121.48	448,623.15
Pool Total	505836.7	512407.8

30 Day Median Pool Concentrations			Average
Boron pool (mMole/L)	248.9	252.1	250.5
Boron pool (mg/L)	2690.6	2725.5	2708.0
Boric Acid (g/L)	15,388	15,588	15487.7

8.863434952

30 Day B Min (mM)		
Source	Unit 1	Unit 2
	Min	Min
RCS	3.24	0.34
Acc A	255.94	269.54
		269.82
Acc C	268.80	268.62
RWST	267.78	269.73

30 Day Min (Moles Boron in each		
Source	Unit 1	Unit 2
	Min	Min
RCS	901.00	95.25
Acc A	8965.52	9441.83
Acc B	9415.91	9451.55
Acc C	9415.91	9409.43
RWST	441606.26	444809.62
Pool Total	470304.60	473207.67

30 Day Min Pool Concentrations			Average
Boron pool (mMole/L)	231.4	232.8	232.1
Boron pool (mg/L)	2501.6	2517.0	2509.3
Boric Acid (g/L)	14,307	14,395	14351.0

30 Day B Max (mg/L)		
Source	Unit 1	Unit 2
	Max	Max
RCS	2797.00	3105.00
Acc A	2947.00	2951.00
Acc B	2933.00	2950.00
Acc C	2942.00	2952.00
RWST	2958.00	2962.00

30 Day Max (Moles Boron in each		
Source	Unit 1	Unit 2
	Max	Max
RCS	258.72	287.21
Acc A	272.59	272.96
Acc B	271.30	272.87
Acc C	272.13	273.06
RWST	273.61	273.98
Pool Total	1348.35	1380.08

30 Day Max (Moles Boron in each source)		
Source	Unit 1	Unit 2
	Max	Max
RCS	72002.73	79931.53
Acc A	9548.75	9561.71
Acc B	9503.39	9558.47
Acc C	9532.55	9564.95
RWST	451216.35	451826.51
Pool Total	551803.77	560443.18

30 Day MaxPool Concentrations			Average
Boron pool (mMole/L)	271.5	275.7	273.6
Boron pool (mg/L)	2935.1	2981.0	2958.0
Boric Acid (g/L)	16,786	17,049	16917.5

Boron concentrations and TSP concentration from evaluation of STP operating Record

RCS Cases (mg/L)		
Range	Unit 1	Unit 2
Min	35.0	3.7
Max	2797.0	3105.0

RCS Cases (mM)		
Range	Unit 1	Unit 2
Min	3.2	0.3
Max	258.7	287.2

RCS Cases (Moles B)		
Range	Unit 1	Unit 2
Min	901.0	95.2
Max	72002.7	79931.5

B Pool concentration as a function of RCS range		
Range	Unit 1	Unit 2
Min (mM)	233.9	234.8
Max (mM)	270.2	274.1

Range dictated by operating conditions	
Test Section	pH
Median	7.174
Maximum	7.25
Minumm	7.082

Range to be covered by	
Test Section	pH
Median (tank test)	7.174
Minimum (Bench test)	4.56
Maximum (Tank test)	7.68

VM input file		
Analyte	mM	
Standard Condition, T= 21		
PO4 (mM)	8.86	
Na (Mm)	26.59	
Changing Concentrations		pH
Average B 30 D2	250.49	7.174
B RCS Min+ Median	233.89	7.24
B RCS Max + Media	274.05	7.087
Total B min	231.4	7.25
Total B Max	275.7	7.082

<------------------- pH determined using VisualMINTEQ with the identified input file

Water summary used in analysis

	Best Estimate Mass (lbs) from Alion		
Source	SBLOCA	MBLOCA	LBLOCA
RWST	3630265	3630265	3630265
RCS	612644	612644	612644
SI Accumulators	0	231334	231334
Total Water in Containment	4242909	4474243	4474243

Source	SMBLOCA (lb)	% contribution	MBLOCA and LBLOCA (lb)	% contribution
RWST	3,630,265	86%	3,630,265	81%
Accum	0	0%	231,334	5%
RCS	612,644	14%	612,644	14%
Total Mass	4,242,909	100%	4,474,243	100%

Source	lbs	Kg	m3	ft3	Liters	Contribution
RWST	3,630,265	1,645,814	1,649	58,238	1,649,121	81%
RCS	612,644	277,748	278	9,828	278,306	14%
Accum	231,334	104,877	105	3,711	105,088	5%
Total	4,474,243	2,028,439	2,033	71,778	2,032,515	100%

21.0 °C Density of water 9.74

997.9948 kg/m^3 or g/L

0.45335924 kg/lb 453.35924 g/lb

0.02831685 ft3/m3

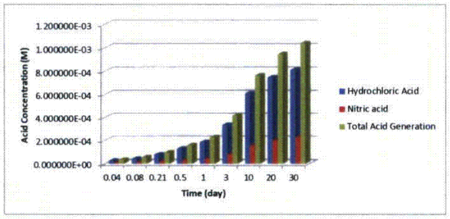
Acid Generation Calcualtion

Time Step		Running Talley		Amount added at each step		Amount added at each step		Amout of concentrate to add		
hour	Day	HNO3 (M)	HCL (M)	HNO3 (M)	HCL (M)	HNO3 (mM)	HCL (mM)	HNO3 (ml)	HCL (ml)	Total (M)
1	0.04	8.19130E-06	2.695920E-05	0.0000082	0.0000270	8.19E-03	2.70E-02	0.59	2.53	3.52E-05
2	0.08	1.12800E-05	4.423080E-05	0.0000031	0.0000173	3.09E-03	1.73E-02	0.22	1.62	5.55E-05
5	0.21	1.76750E-05	8.000920E-05	0.0000064	0.0000358	6.40E-03	3.58E-02	0.46	3.36	9.77E-05
12	0.5	2.81870E-05	1.294720E-04	0.0000105	0.0000495	1.05E-02	4.95E-02	0.76	4.64	1.58E-04
24	1	4.21200E-05	1.844460E-04	0.0000139	0.0000550	1.39E-02	5.50E-02	1.01	5.16	2.27E-04
72	3	8.13400E-05	3.341630E-04	0.0000392	0.0001497	3.92E-02	1.50E-01	2.84	14.05	4.16E-04
240	10	1.53660E-04	6.104420E-04	0.0000723	0.0002763	7.23E-02	2.76E-01	5.23	25.93	7.64E-04
480	20	1.99350E-04	7.480900E-04	0.0000457	0.0001376	4.57E-02	1.38E-01	3.30	12.92	9.47E-04
720	30	2.28740E-04	8.118600E-04	0.0000294	0.0000638	2.94E-02	6.38E-02	2.13	5.99	1.04E-03
Total				0.0002287	0.0008119	2.29E-01	8.12E-01	16.55	76.20	

Tank	
300	gal
1135.623534	Liters

Acid Information

Concentrate	Manufacture	Part number	Molarity
Nitric Acid	EMD	NX0409P-5	15.7
Hydrochloric Acid	EMD	HX0603P-5	12.1



Day	HNO3 (mM)	HCL (mM)	
0.04	8.19E-03	2.70E-02	
0.08	3.09E-03	1.73E-02	
0.21	6.40E-03	3.58E-02	
0.50	1.05E-02	4.95E-02	
1.00	1.39E-02	5.50E-02	
3.00	3.92E-02	1.50E-01	
10.00	7.23E-02	2.76E-01	Test initiation
20.00	4.57E-02	1.38E-01	Day 1
30.00	2.94E-02	6.38E-02	Day 3
			Day10
			Day 20

hour	HNO3 (ml)	HCL (ml)
1	0.59	2.53
2	0.22	1.62
5	0.46	3.36
12	0.76	4.64
24	1.01	5.16
Summary of 24 h	3.05	17.31
3	2.84	14.05
10	5.23	25.93
20	3.30	12.92
30	2.13	5.99